

CLAIMS

What is claimed is:

1. A user interface device to manipulate a position of a cursor on a screen display in an electronic apparatus, comprising:

a tracking element actuatable to track the position of said cursor on said screen display;

at least one motor interconnected to said tracking element and having a position encoder connected thereto, each said position encoder generating a motor position signal indicative of the position of a respective motor;

a controller receiving cursor position information from said electronic apparatus and motor position information from a respective encoder;

a store of force-position information accessible to said controller, said controller accessing said store of force-position information in response to at least one of said cursor position information and said motor position signal to generate, using said at least one motor, a positive or negative force in said tracking element as a function of a position of said cursor on said screen display.

2. The user interface device of claim 1 wherein said tracking element is a sphere interfaced to said at least one motor by at least two sets of wheels contacting said sphere and said at least two sets of wheels are aligned on mutually orthogonal axes.

23 3. The user interface device of claim 2 wherein each of said at
24 least two sets of wheels comprises a hub about which a pair of
25 frames is disposed and each of said pair of frames includes
26 gripping members staggered in a manner so that there is always a
27 gripping member in contact with said sphere.

28 4. The user interface device of claim 1 wherein said at least one
29 motor comprises a plurality of motors and each of said plurality of
30 motors has an associated complementary motor connected in series.

31 5. The user interface device of claim 1 wherein said at least one
32 motor comprises a plurality of motors and each of said plurality of
33 motors has an associated complementary bearing.

34 6. The user interface device of claim 1 wherein said at least one
35 motor comprises a plurality of motors each interconnected to said
36 tracking element by at least one set of wheels aligned on mutually
37 orthogonal axes and configured to sense or impart motion of the
38 tracking element on a respective axis.

39 7. The user interface device of claim 6 wherein said plurality of
40 motors each interconnected to said tracking element by at least one
41 set of wheels aligned on mutually orthogonal axes are configured to
42 sense or impart motion of the tracking element on mutually
43 orthogonally disposed x and y-axes.

44 8. The user interface device of claim 7 further including at
45 least one set of wheels configured to sense or impart motion of the
46 tracking element on a z-axis orthogonally disposed with respect to
47 said x and y-axes.

48 9. A method of generating tactile responsiveness in a user
49 interface device having a tracking element manipulating a position
50 of a displayed element on a display screen of an electronic device,
51 said method comprising the steps of:

52 positioning a plurality of drive/position assemblies along
53 mutually orthogonal axes with respect to said tracking element,
54 each of said plurality of drive/position assemblies including a
55 motor and an associated encoder to drive and sense position of said
56 tracking element;

57 interfacing said user interface device to said display screen
58 via a controller that receives information from said associated
59 encoder of each of said plurality of drive/position assemblies and
60 from said electronic device to track movement of said tracking
61 element and the position on said display screen of said displayed
62 element;

63 storing force-position relation information, accessible to
64 said controller, as a function of the position on the display
65 screen of the displayed element; and

66 accessing said force-position information via said controller
67 and generating a signal to each of said plurality of drive/position
68 assemblies to effect a positive or negative force to respectively

69 assist or resist motion of said tracking element depending upon the
70 position of said displayed element on said display screen.

71 10. The method of claim 9 wherein said step of positioning a
72 plurality of drive/position assemblies further includes positioning
73 a corresponding plurality of complementary slave assemblies along
74 corresponding mutually orthogonal axes, each of said complementary
75 slave assemblies being electrically connected in series with a
76 respective one of said plurality of drive/position assemblies.

77 11. The method of claim 9 wherein the step of interfacing said
78 user interface device to said display screen via said controller
79 includes interconnecting said electronic device to said controller
80 to send and receive information about the position of the displayed
81 element on said display screen between said electronic device and
82 said controller, and interconnecting said plurality of
83 drive/position assemblies to said controller to send said signal to
84 each of said plurality of drive/position assemblies to effect said
85 positive or negative force to respectively assist or resist motion
86 of said tracking element depending upon the position of said
87 displayed element on said display screen.

88 12. A user interface device having tactile feedback capabilities,
89 comprising:

90 an actuatable member for imparting a tactile feedback to a
91 user of said user interface device;

92 a motor interconnected to said actuatable member;
93 a position encoder in communication with said motor, said
94 position encoder providing position information of said motor;
95 a controller receiving said position information from at least
96 said position encoder;
97 a store of force-position relation information accessible to
98 said controller, said controller outputting at least one force
99 value corresponding to said position information in accordance with
100 said store of force-position relation information; and
101 a drive signal source generating a drive signal to said motor
102 in accordance with said at least one force value, said drive signal
103 causing a force in said motor to provide said tactile feedback to
104 said actuatable member to assist or resist motion of said
105 actuatable member.

106 13. The user interface device of claim 12 further including a
107 counter receiving said position information of said motor and
108 providing a count to said controller, said controller outputting a
109 force value corresponding to said position information in
110 accordance with said store of force-position relation information.

111 14. The user interface device of claim 13 wherein said force value
112 is a digital force value and further including a digital to analog
113 converter receiving said digital force value and converting said
114 digital force value to an analog force signal.

115 15. The user interface device of claim 14 further including a
116 power amplifier receiving said analog force signal and generating
117 said drive signal to said motor in accordance with said at least
118 one force value, said drive signal being proportional to said
119 analog force signal.

120 16. The actuator of claim 12 wherein said controller is a
121 microprocessor receiving said position information on at least one
122 port thereof.

123 17. The actuator of claim 16 wherein said microprocessor includes
124 resident erasable programmable read only memory which is used for
125 said store of force-position relation information.

126 18. The actuator of claim 12 wherein said drive signal source is
127 a current source including a power amplifier and said drive signal
128 is a current provided by said power amplifier.

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